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THE SOY BEAN, WITH SPECIAL REFERENCE TO ITS UTILIZATION FOR OIL, CAKE, AND OTHER PRODUCTS.

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INTRODUCTION.

The soy bean, although a plant of ancient cultivation in China, Chosen (Korea), and Japan, has become of special importance in the world's commerce only within recent years. In extent of uses and value it is the most important legume grown in Asiatic countries. In these countries the soy bean is used to a very considerable extent for human food, the beans being prepared in various ways. As the bean contains a valuable oil, large quantities are utilized by first extracting the oil and then using the cake for stock feed and as a fertilizer.

Previous to the Russian-Japanese war, China and Japan were not only the greatest producers but also the greatest consumers of the soy bean and its manufactured products. About 1908 the first large importations of beans were received in Europe and America from Manchurian ports. The beans were utilized by extracting the oil, which was found valuable for various industrial purposes, leaving the bean cake as a stock feed. As the value of the oil and cake came to be recognized, new uses and markets were found, and the trade in soy beans became one of great importance, until now it has assumed

Note.—This bulletin is intended for general distribution in the Southern States, where it will be of special interest to farmers and cotton-oil millmen. It will also be of interest to farmers of the Northern and Central States and to manufacturers of soy-bean food products.

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such large proportions that the soy bean has become an important competitor of other oil seeds.

As early as December, 1915, several American cotton-oil mills had turned to the soy bean as a source of oil and meal on account of the scarcity and high price of cottonseed.[1] Other manufacturers are preparing soy-bean products for human food. This utilization of American-grown beans for the manufacture of oil, cake, and other products will undoubtedly greatly stimulate the culture of the crop, which until now has been grown in the United States primarily for forage.

FIG. 1.—A fleet of junks engaged in carrying soy beans to Newchwang, Manchuria, from different points in the interior, taking away bean oil and bean cake to other places. (Photographed by F. N. Meyer.)

SOY BEANS IN MANCHURIA.

The soy bean is grown in nearly all parts of Manchuria where agriculture is conducted except in the extreme north. The beans, together with their products—bean cake and oil—form the chief exports (fig. 1). The soy bean is always relied upon by the Manchurian farmer as a cash crop and constitutes a staple product of Manchurian agriculture.

The conditions under which the soy bean thrives are said to be far more varied in Manchuria than in the United States. It is grown

[1] The average market price of cottonseed in the cotton-producing States during the past three years is shown by the following figures, furnished by the Bureau of Crop Estimates: September 15, 1914, $13.88 per ton; September 15, 1915, $20.98 per ton; September 15, 1916, $41.13 per ton.

successfully in semiarid regions, in valleys subject to floods in the rainy season, and in northern latitudes similar to the Dakotas and Minnesota.

In Manchuria the beans are almost entirely produced by hand methods. The seed is usually planted in April in rows 17 inches apart, the plants about 2 inches apart in the rows. In some districts, however, the beans are planted in 24-inch rows, allowing about 7 plants to the foot. The harvest takes place in September, the plants commonly being pulled before they are quite mature, to avoid shattering the pods. The thrashing of the seed is usually accomplished with a stone roller or by trampling, and the winnowing by throwing the beans against the wind.

The beans are bought by Chinese merchants and stored at railway stations. No grading is attempted, the stored beans being of all varieties and mixed more or less with sand and trash. The exporters buy the beans from these merchants simply by weight, but before shipment the beans are sorted.

As to the yields obtained by the Manchurian farmer, there is considerable variation in the figures given by different authorities. Bean experts estimate the yield from 1,100 to 1,600 pounds to the acre, commercial authorities from 1,600 to 1,800 pounds, and Japanese agricultural experts from 400 to 2,000 pounds. In the best bean-producing districts the average yield is said to be more than 1,800 pounds. No reliable statistics as to the cost of production are available, but according to data secured from bean growers the approximate cost per acre is placed at $4.42.

Previous to the Russian-Japanese war soy beans and their products were exported almost entirely to Asiatic countries, Japan being the principal consumer. During the war the local demand greatly increased the production of the crop throughout Manchuria. After the withdrawal of the troops, however, it became necessary to find new markets for the surplus beans. Trial shipments were made about 1908 by Japanese firms to several English oil mills. The suitability of the seed for oil and cake was quickly recognized, and orders for large consignments were made. The bean trade grew rapidly and extended to other European countries and to America. The exports of beans from Manchurian ports have increased and large quantities of oil and cake are exported annually, as shown in Table I.

The ports of Antung, Dairen, and Newchwang are the principal centers of exports from southern Manchuria. Table I shows the exports of beans, bean cake, and bean oil passing through these ports for the years 1909 to 1913, inclusive. Beans from North Manchuria are exported chiefly through Vladivostok, the export figures for beans for the years 1912 and 1913 amounting to 338,451 tons and

391,410 tons, respectively. Adding these quantities to the exports of South Manchuria gives 654,705 tons for 1912 and 599,278 tons for 1913, which may be taken as representing the total exports of beans from Manchuria for these two years.

TABLE I.—*Exports of soy beans, bean cake, and bean oil from the principal ports of South Manchuria, 1909 to 1913, inclusive.*[1]

Exports and ports.	1909	1910	1911	1912	1913
Soy beans:	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Antung	1,643.4	136.1	4,591.5	3,639.8	5,225.6
Dairen	512,469.0	359,665.3	268,732.4	182,628.6	169,300.8
Newchwang	237,020.6	174,562.7	154,187.3	129,985.1	105,341.8
Total	751,133.0	534,364.1	427,511.2	316,253.5	279,868.2
Bean cake:					
Antung	16,349.6	12,054.0	33,166.5	40,111.1	42,322.2
Dairen	318,825.5	277,423.7	463,546.2	378,722.7	566,135.7
Newchwang	356,499.4	327,098.5	386,599.1	282,877.9	298,364.0
Total	691,674.5	616,576.2	883,311.8	701,711.7	906,821.9
Bean oil:					
Antung	92.7	149.6	365.7	558.4	192.1
Dairen	10,850.3	18,753.2	33,729.7	37,466.7	43,392.3
Newchwang	37,875.2	21,356.2	28,039.1	21,826.2	20,752.9
Total	48,818.2	40,259.0	62,134.5	59,851.3	64,337.3

[1] Compiled from U. S. Dept. Com., Daily Cons. and Trade Rpts., No. 115, p. 922, May 16, 1914. (Hanson, G. C. Manchuria's soya-bean trade.)

SOY BEANS IN JAPAN.

The soy bean is cultivated quite extensively throughout the Empire of Japan and occupies about 3.8 per cent of the total area devoted to the cultivation of rice and other cereals. In many districts it is cultivated not in fields by itself, but in rows along the edges of rice and wheat fields. Although not grown to any considerable extent as a main crop by the Japanese farmer, the average annual production is about 18,000,000 bushels. In quality the beans raised in Japan are said to be superior to those of Manchuria and Chosen and are used exclusively in the manufacture of food products. The imported beans, of which very large quantities are obtained from Manchuria and other Asiatic countries, are used principally in the manufacture of bean cake and oil.

The methods of culture of this crop, though varying slightly in different provinces, are quite similar to those employed in Manchuria. The average yield of soy beans to the acre for the last 10 years is 15.3 bushels. The highest average yield recorded is 21.6 bushels to the acre, while the lowest average yield is 8.48 bushels. Accurate data as to the cost of production are not available, but estimates made by Japanese agricultural experts place it at about $10 per acre exclusive of taxes. The average market price in Japan for home-grown beans is about $1 a bushel, while for imported beans it is about 70 cents a bushel.

The soy bean forms one of the most important articles of food in Japan. It is one of the principal ingredients in the manufacture of shoyu (soy sauce), miso (bean cheese), tofu (bean curd), and natto (steamed beans). The beans are eaten also as a vegetable and in soups; sometimes they are picked green, boiled, and served cold with soy sauce, and sometimes as a salad. A "vegetable milk" is also produced from the soy bean, forming the basis for the manufacture of the different kinds of vegetable cheese. This milk is used fresh, and a form of condensed milk is manufactured from it. All of these foodstuffs are used daily in Japanese homes and for the poorer classes are the principal source of protein. To a limited extent, soy beans are used as a horse or cattle feed, being sometimes boiled and mixed with straw, barley, and bran.

Table II shows the exports of soy beans and bean oil from Japan during 1913 and 1914. Prior to 1914 soy beans were not listed separately.

TABLE II.—*Quantity and value of exports of soy beans and soy-bean oil from Japan to foreign countries, 1913 and 1914.*[1]

Country of destination.	Soy beans.		Soy-bean oil.			
	1914		1913		1914	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*	
China	62,820	$1,372	220,155	$11,328	184,104	$10,198
United Kingdom	589	21	214,491	11,570	1,019,854	48,687
France			73,890	3,907		
Germany			66	3	10,979	588
Belgium			69,057	3,405	333,735	16,573
United States	421,011	10,125	658,393	34,386	365,478	19,393
Hawaii	203,560	5,296				
British America	246,175	4,540	56,218	3,234	69,652	3,196
Australia	18,070	475	587,413	30,101	120,240	748
Other countries	20,967	504			274,080	18,542
Total	973,192	22,333	1,879,683	97,934	2,378,122	117,925

[1] Compiled from Annual Return of the Foreign Trade of the Empire of Japan, 1914.

As previously stated, Japan has been a large consumer of soy beans and soy-bean products from Manchuria, the greater part of the beans being used in the manufacture of oil and cake. The imports from Dairen, Manchuria, the principal port through which beans and bean products are exported to Japan, are shown for the years 1911 to 1914, inclusive, in Table III.

TABLE III.—*Quantity of imports of soy beans, soy-bean cake, and soy-bean oil from Dairen, Manchuria, into Japan, 1911 to 1914, inclusive.*[1]

Product.	1911	1912	1913	1914
	Tons.	*Tons.*	*Tons.*	*Tons.*
Soy beans	162,703	103,416	90,651	139,222
Soy-bean cake	357,362	357,752	492,985	447,080
Soy-bean oil	9,340	10,889	3,964	4,107

[1] Compiled from Dairen Wharf Office Returns, 1911–1914.

SOY BEANS IN EUROPE.

The soy bean was first introduced into Europe about 1790 and was grown for a great number of years without attracting any attention as a plant of much economic importance. In 1875 Professor Haberlandt, of Vienna, began an extensive series of experiments with this crop and strongly urged its use as a food plant for man and animals. Although interest was increased in its cultivation during the experiments, the soy bean failed to become of any great importance in Europe. At the present time it is cultivated only to a limited extent in Germany, southern Russia, France, and Italy.

Attempts have been made at various times to introduce the soy bean and its products into European markets in competition with manufactures from other oil seeds. Owing to the inferior quality of the beans and cake received, these efforts were generally unsuccessful. About 1908, the first large trial shipment of beans was made to England. As these were received in much better condition than those of previous shipments, the results obtained were so satisfactory that, in 1909, 412,757 tons, in 1910, 442,669 tons, and in 1911, 321,940 tons were imported by European oil mills.

Nearly all of the first large importations of beans were taken by England, where many of the large oil mills devoted their plants entirely to the crushing of soy beans. At this time impetus was given to the manufacture of soy-bean products by a shortage of cottonseed and linseed in England, so the soy bean found a ready market.

Several English firms manufacturing oil-seed cake conducted a series of tests, successfully demonstrating the utilization of the cake, meal, and oil of the soy bean. The cake or meal was soon recognized as a valuable stock feed in the dairy countries, such as Holland and Denmark, where large quantities of oil-seed products are used. The oil was found useful for many trade purposes. The oil and cake were offered at prices which made soy-bean products strong competitors of cottonseed manufactures.

The utilization of the soy bean as an oil seed extended rapidly to the continental countries, and the importations of beans from Manchuria soon reached enormous proportions. That the soy bean and its products have become fully established on the European market is shown in Table IV.

TABLE IV.—*Quantity and value of imports of soy beans, bean cake, and bean oil by European countries, 1912 to 1914, inclusive.*[1]

Product and country.	1912		1913		1914	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Soy beans:	*Tons.*		*Tons.*		*Tons.*	
United Kingdom	188,760	$7,630,477	76,452	$3,093,863	71,161	$2,886,759
Germany	96,068	3,974,837	107,504	3,974,838	12,843	480,401
Netherlands	42,373	1,592,690	27,119	1,019,317	19,308	725,721
Russia	695	30,250	267,036	6,461,739	.....	.....
Belgium	1,625	61,095	6,438	199,684	1,002	37,564
Denmark	412	14,035	4,425	115,975	8,187	357,434
France	.....	.....	34,318	918,008	.....	.....
Total	329,933	13,303,384	523,292	15,783,424	112,501	4,487,879
Soy-bean cake:						
Netherlands	23,852	836,269	7,230	250,459	1,235	43,964
Germany	7,080	252,912	3,260	111,015	1,201	41,258
Russia	2,059	72,136	21,969	396,944	195	6,507
Denmark	7,620	252,834	15,490	520,857	4,964	164,332
Sweden	4,051	139,391	2,695	91,714	989	33,394
France	1,952	69,367	400	14,016	230	7,903
Total	46,614	1,622,909	51,044	1,385,005	8,814	297,358
Soy-bean oil:						
Netherlands	4,558	250,422	2,828	154,691	10,015	547,820
Belgium	2,083	278,569	363	45,389	137	16,957
Italy	2,252	356,006	4,642	735,490	5,830	953,403
Sweden	1,116	154,434	578	78,491	313	41,867
Austria	617	99,797	1,314	206,078	1,395	224,565
Germany	10,902	1,450,134	3,090	396,032	2,459	296,966
France	1,693	249,486	83	11,397	208	26,917
Russia	.....	.....	5,150	508,076	.....	.....
United Kingdom	.....	.....	95	11,570	455	48,687
Total	23,221	2,838,848	18,143	2,147,214	20,812	2,157,182

[1] Compiled from Koninkryk der Nederlanden, Statistiek van den in-, uit- en doorvoer; Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions; Statistik des Deutschen Reichs, Auswärtiger Handel.

SOY BEANS IN THE UNITED STATES.

Although the soy bean was mentioned as early as 1804 [1] it is only within recent years that it has become a crop of importance in the United States. At the present time the soy bean is most largely grown for forage. In a few sections, such as eastern North Carolina, however, a very profitable industry has developed from the growing of seed. The large yield of seed, the ease of growing and harvesting the crop, the value of the beans for both human and animal food, and the value of the oil all tend to give this crop a high potential importance and assure its greater agricultural development in America.

The soy bean can be grown successfully on nearly all types of soil and has about the same range of climatic adaptation as varieties of corn. The cotton belt and the southern part of the corn belt are most favorably situated for the production of seed of this crop (fig. 2). The yields of seed to the acre in various sections of the United States range from about 15 bushels in the Northern States to about 40 bushels in the northern half of the cotton belt. The average yield in eastern

[1] Willich, A. F. M. American Encyclopedia, 1st Amer. ed., v. 5, p. 13. Philadelphia, 1804.

North Carolina is about 25 bushels, although many fields produce 35 bushels or more to the acre.

The growing and handling of soy beans are accomplished almost entirely by machinery in this country, the ordinary farm equipment meeting all the requirements of this crop. In large bean-growing districts, special harvesters for gathering the seed in the field are used quite successfully. The cost of production varies from $7.50 to $12 per acre, depending on the methods employed in growing and handling the crop. The market price per bushel of seed for sowing purposes varies in different sections, ranging from $1 in large seed-producing sections of the South to $2 or $3 a bushel in the Central and Middle States.

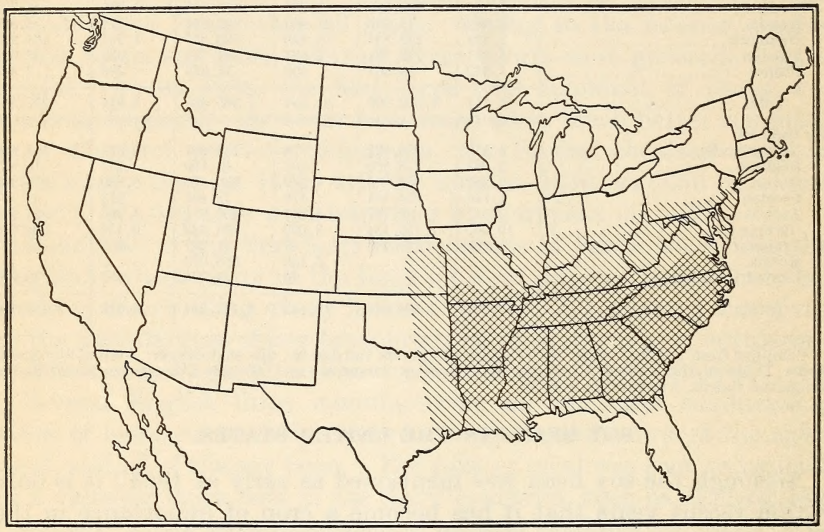

FIG. 2.—Outline map of the United States, showing by double hatching the area to which the soy bean is especially adapted for growing for oil production. The area where the soy bean is less certain of profitable production for oil purposes is shown by single lines.

The first extensive work in the United States with the soy bean as an oil seed was entered upon about 1910 by an oil mill on the Pacific coast. The beans, containing from 15 to 19 per cent of oil, were imported from Manchuria, and the importations, most of which are used in the manufacture of oil and cake, have gradually increased, as shown in Table V. The oil was extracted with hydraulic presses, using the same methods employed with cottonseed and linseed. It found a ready market, as a good demand had been created for this product by soap and paint manufacturers, which up to this time had been supplied by importation from Asiatic countries and England. The soy cake, ground into meal, was placed on the market under a trade name and was soon recognized as a valuable feed by dairymen and poultrymen. The use of the

cake has been confined almost wholly to the Western States, owing principally to the high cost of transportation.

During the last few years efforts have been made at various times to interest the cotton-oil mills of the South in the utilization of American-grown soy beans as an oil seed, and experiments were made by a few mills. No extensive work was entered upon until the latter part of 1915. A shortage of cottonseed in the South and a surplus of soy-bean seed in eastern North Carolina led to an increased interest in the possibilities of this crop. Several cotton-oil mills in North Carolina, after preliminary tests, entered upon an extensive production of soy-bean oil and meal. This is the first large manufacture of soy-bean products from American-grown seed. Several cotton-oil mills at the present time are taking an active part in the development of this new industry with American-grown beans. With seed at $1 a bushel and the present prices received for oil and cake, the mills have found it profitable for them to express the oil.

An industry which promises to be of importance in a further utilization of the soy bean is the manufacture of "vegetable milk." At the present time a factory in New York State is being equipped for this purpose. The development of this new enterprise will depend primarily upon the demand created among different industries not only for the milk, but for the flour or meal remaining after the milk is manufactured, which is valuable either as stock feed or for human consumption.

Table V shows the imports of soy beans, bean cake, and bean oil into the United States during the last six years. Prior to 1914 soy beans were not classified separately in the customs returns.

TABLE V.—*Quantity and value of imports of soy beans, soy-bean cake, and soy-bean oil into the United States, 1910 to 1915, inclusive.*[a]

Year.	Soy beans.		Soy-bean cake.		Soy-bean oil.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*	
1910	.....	.....	.....	.....	Not stated.	$1,019,842
1911	.....	.....	[b] 2,115,422	$59,626	41,105,920	2,555,707
1912	.....	.....	[b] 2,416,052	64,350	28,019,560	1,576,968
1913	.....	.....	7,004,803	93,002	12,340,185	635,882
1914	1,929,435	$49,507	3,163,260	38,255	16,360,452	830,790
1915	3,837,865	87,306	5,975,592	64,307	19,206,521	899,819

[a] Compiled from Dept. Com., Bur. For. and Dom. Com. For. Com. and Nav. U. S. 1910–1915.
[b] Includes bean cake, or bean stick, miso, or similar products, with duty, 40 per cent.

METHODS OF OIL EXTRACTION.

The introduction of the soy bean into the Western World for oil purposes has not made any changes necessary in the equipment of the modern oil mills. The methods used in the extraction of oil from

the soy bean are similar to those employed with other oil seeds, such as cottonseed and linseed.

In Manchuria the manufacture of oil and oil cake is not confined to large centers, as every small center of bean production has its native mill. The method of extracting oil in these native mills is decidedly primitive. The beans are first crushed beneath a millstone and then steamed for about 15 minutes. The resultant mass is spread out and placed in circular iron frames, about 6 inches deep. Five of these frames are placed one above another in a vertical press, consisting of four uprights, with crossbeams at the top and bottom. Pressure is applied by means of wedges driven in between the cross-

FIG. 3.—Coolies at Newchwang, Manchuria, engaged in carrying loads of soy beans from the junks to big stacks, where they are kept until the factory needs them for oil manufacture. (Photographed by F. N. Meyer.)

beams and beams placed on top of the frames, and the oil is thus expressed. During the last few years large bean mills equipped with modern machinery have been erected, and these are able to extract 3 or 4 per cent more oil (fig. 3). In these large bean mills only about one-half the oil is extracted by the usual process; that is, by crushing the beans, steaming them, and using hydraulic pressure.

A solvent process of extraction, involving the use of benzine, has recently come into use in several English mills, and three such mills are in operation in Manchuria and Japan. The seeds are first finely crushed and then treated directly by the fat solvent. The oil is then taken out of the fat solvent by evaporating the latter, which is distilled and used over again. The residue is well dried and then ground into a fine meal, which is said to contain no detectable trace

of the solvent. By this process, nearly all of the oil is extracted, the meal containing only about 1.5 per cent of oil, and 43 to 45 per cent of protein. It is contended that by the solvent process more oil of a better quality is extracted from the beans and the resultant meal is better suited for flour or fertilizer, as it contains less oil. A solvent-process mill recently erected in Manchuria has a maximum capacity of 80 tons of beans every 24 hours. However, only 50 tons of beans were crushed daily, producing 7 tons of oil and 40 tons of meal, the 3 tons which were lost consisting of moisture, dust, and dirt.

In the United States two methods of oil extraction—the hydraulic and the expeller processes—are used by the oil mills. Analyses of cake produced by these methods show about 9 per cent of oil by the hydraulic method and from 4 to 6 per cent by the expeller method. While the cost of producing oil and cake with either process is less with the soy bean than with cottonseed, the cost is much less with the expeller process and a greater amount of oil is extracted. Extensive tests with domestic beans indicate that 1 ton of seed will yield by the expeller process an average of 30 gallons of oil and 1,600 pounds of meal, the difference (about 175 pounds) representing the loss due to cleaning and the evaporation of moisture driven off after the beans have been crushed and heated. The amount of moisture contained in the seeds appears to be a matter of importance in Manchuria, not only for the dealer shipping the beans but also for the mill owner. It has been estimated that 48 pounds of the 1913–14 Manchurian crop yielded 4.7 pounds of oil, while only 4.1 pounds could be expressed from the same quantity of the 1914–15 crop.

SOY-BEAN MEAL AS HUMAN FOOD.

The meal remaining after the oil is extracted from Mammoth soy beans is bright yellow in color when fresh and has a sweet, nutty flavor. The use of the meal as flour for human food has become an important factor in several European countries during the last few years and to some extent in America as a food of low starch content. Soy beans contain at the most but a slight trace of starch, and extensive experiments in America and Europe indicate the value of the bean and its products as the basis of foods for persons requiring a low starch diet.

In England, manufacturers have placed on the market a so-called "soya flour," which is 25 per cent soy-bean meal and 75 per cent wheat flour. This soya flour is being used by bakers in making a soy bread which is very palatable and may be found on the market. A similar product has been manufactured in Amsterdam for 25 years. "Soya biscuits" are also manufactured from this flour and constitute an article of export from England.

German millers have been experimenting to some extent with soy meal in making brown bread by mixing with rye flour. As to the extent to which this bread is now used, no data are available, but it is known that soy meal, on account of the large proportion of protein and phosphates it contains, as well as the palatable products made from it, is gaining in popularity. Soy-bean flour enters largely as a constituent in many of the so-called diabetic breads, biscuits, and crackers manufactured as food specialties.

As a human food, soy-bean flour has been used principally in the United States as a special article of diet and is sold by a number of food companies manufacturing special foods. Extensive tests are being conducted by the United States Department of Agriculture with soy-bean flour in the making of bread.[1] The flour or meal can be successfully used as a constituent for muffins, bread, and biscuits in much the same way as corn meal. In these various food products about one-fourth soy flour and three-fourths wheat flour have been found to be the proper proportions. When a special food of low starch content is desired, as for diabetic persons, a larger proportion of soy flour is used and some form of gluten is substituted for the wheat flour. The addition of the soy flour changes the proportion of protein and carbohydrates in the mixture, as will be noted from the composition of flours shown in Table VI.

TABLE VI.—*Composition of soy-bean flour in comparison with wheat flour, corn meal, rye flour, Graham flour, and whole-wheat flour.*[2]

Kind of flour or meal.	Constituents (per cent).					
	Water.	Ash.	Fat.	Fiber.	Protein.	Carbohydrates.
Soy bean[1]	6.14	5.24	20.71	1.72	39.56	26.63
Soy bean[2]	6.10	6.20	4.50	2.05	47.30	33.85
Wheat	12.00	.45	1.00	.20	11.00	75.35
Corn meal	10.00	.90	2.70	.80	8.50	77.10
Rye	9.00	1.10	1.50	.65	12.00	75.85
Graham	9.60	1.80	2.20	1.90	12.60	71.90
Whole wheat	10.90	1.05	2.00	1.00	12.00	73.05

[1] Flour made from the whole soy bean. [2] Flour made from soy-bean cake.

Although soy-bean milk has been used in both the fresh and the condensed form and in the manufacture of cheese in Japan and China for centuries, it only recently has been considered of possible importance in the United States. Soy-bean milk, owing to its food value and for sanitary reasons, is said to be of the greatest importance for cooking purposes and can be used by bakers, confectioners, and chocolate manufacturers. In Asiatic countries the whole bean is

[1] Attention has been given to the food value of soy beans in connection with studies carried on by the Office of Home Economics. See U. S. Dept. Agr., Farmers' Buls. 58 and 121 and Office Expt. Stas. Bul. 159.

[2] Reported by the Bureau of Chemistry.

utilized in the manufacture of the milk, but quite recently it has been discovered that soy-bean meal, after the oil is extracted, is fully as useful for milk purposes as the whole bean.

If the milk from the soy bean is used in the manufacture of products as a substitute for milk, the labels of such products should indicate that the substitution has been made; otherwise it would constitute adulteration under the food and drugs act.

In addition to its uses for flour and milk, the soy bean can be prepared as human food in numerous ways. The green bean, when from three-fourths to full grown, has been found to compare favorably with the butter or Lima bean. The dried beans may be used in the same way as the field or navy bean in baking or in soups. When prepared in either of these ways the dried beans require a somewhat longer soaking and cooking. The soy bean has been utilized not only in the United States but in European countries as a substitute for the coffee bean. When roasted and prepared, it makes an excellent substitute for coffee. In Asia the dried beans, especially the green-seeded varieties, are soaked in salt water and then roasted, this product being eaten after the manner of roasted peanuts.

SOY-BEAN MEAL AS STOCK FEED.

Soy-bean meal, in addition to its use as a fertilizer, is also used as stock feed. In Manchuria the cake or meal, mixed with bran and kaoliang stalks, is used as feed for horses and mules, but only when very hard work is done. It is also recognized in Japan as a valuable feed for work animals and as a fattening feed for stock not employed in farm work.

In Europe soy-bean cake ground into meal is used almost entirely for feeding cattle, and the low price in comparison with other concentrated feeds has made it very popular. Some hesitation was shown in the dairy countries of Europe when the meal was first introduced, as it was feared that the taste of the butter might be affected by feeding the meal to cows. However, experiments in these countries proved the fear groundless, and the demand for the meal increased steadily. The use of soy-bean meal in America is confined at the present time almost entirely to the Pacific States. It is considered a valuable feed not only by dairymen but also by poultrymen.

Practical experience, supplemented by carefully conducted experiments in the United States and European countries, indicates the high feeding value of soy-bean meal for all kinds of farm stock. The Massachusetts (Hatch) Agricultural Experiment Station conducted a series of tests comparing soy-bean meal with cottonseed meal for feeding dairy cows. It was found that although soy-bean meal imparts a noticeable softness to butter, the cottonseed butter was decidedly inferior in color, flavor, and texture. Doubtless a

mixture of these meals in proper proportions would tend to produce a butter of the proper consistency. The value of soy-bean meal for producing meat, milk, and butter is well established. It is one of the cheapest of the highly nitrogenous feeding stuffs and is therefore one of the most economical for balancing rations deficient in nitrogen.

Table VII shows the prices per short ton of soy-bean cake in comparison with other oil cakes which enter largely into the feeding rations of cattle in European countries.

TABLE VII.—*Value per short ton of soy-bean cake and other oil cakes in the principal European countries.*

[From U. S. Department of Commerce, Special Agent Series No. 84.]

Kind of meal.	Germany.	United Kingdom.	Netherlands.	Denmark.	Sweden.
Cottonseed, American	$35.60	$35.85	$39.00	$36.23	$37.05
Soy bean	32.70	.....	.....	33.80	34.55
Linseed, pressed	32.20	35.84	31.75	33.50	33.40
Peanut, Rufisque	36.60	.....	36.10	35.00	35.25

Alleged injurious effects from feeding soy-bean products have been reported to some extent in the United States and Europe, and their cause has been the subject of careful investigation. As yet, however, no proof is to be had of soy beans or their products causing any injurious effects. Owing to its high content of protein, the meal should be used with the same precautions as are observed with other highly concentrated feeds, to avoid digestive troubles.

Table VIII gives analyses of soy-bean meal compared with similar concentrated feeds. As regards digestibility, soy-bean meal compares very favorably with other oil meals.

TABLE VIII.—*Analyses of soy-bean meal and other important oil meals.*[1]

Kind of meal.	Constituents (per cent).					
	Moisture.	Protein.	Fat.	Nitrogen-free extract.	Ash.	Fiber.
Soy bean	7.59	44.65	8.77	27.12	5.89	5.96
Cottonseed	6.62	40.29	7.41	28.63	6.21	10.84
Linseed (old process)	8.98	33.23	7.20	36.51	5.40	8.68
Linseed (new process)	9.63	37.51	2.49	36.09	5.54	8.74
Peanut (decorticated)	10.73	46.84	7.91	24.34	4.89	5.29
Sunflower seed	7.68	23.80	7.94	27.49	5.03	28.06

[1] Average analyses as reported by the Cattle Food and Grain Investigations Laboratory, Bureau of Chemistry.

SOY-BEAN MEAL AS A FERTILIZER.

The utilization of soy-bean meal for fertilizing purposes has been confined almost entirely to Asiatic countries. For centuries bean cake has been sent to the sugar plantations of southern China, and its use gradually spread to the plantations in Java and other tropical

islands. The high fertilizing value of the cake has long been recognized by the Japanese, who import large quantities annually for use in the rice fields and as an alternative manure for mulberry trees. In Manchuria large amounts of cake are used annually in soils of low fertility for both field and garden crops.

Although large quantities of soy-bean cake have been imported into the United States during the last few years, there is no mention of its use in the manufacture of commercial fertilizers. With the recent production in the Southern States of bean cake and oil from southern-grown beans, fertilizer manufacturers have become interested in the possibilities of the meal and have purchased considerable quantities for this purpose.

Like cottonseed meal, soy-bean meal contains considerable amounts of phosphoric acid and potash, a large proportion of which is "available," but it is principally valued in fertilizers as a source of nitrogen. If the price is determined on the same basis as that used in calculating the fertilizing value of cottonseed meal, the soy-bean meal is a more valuable product. Its composition with reference to fertilizing constituents and a comparison with cottonseed meal are shown in Table IX.

TABLE IX.—*Fertilizing constituents of soy beans, soy-bean meal, and cottonseed meal.*

Crop or product.	Source of data.	Constituents (per cent).			
		Nitrogen.	Ammonia.	Phosphoric acid.	Potash.
Soy beans	Bureau of Chemistry	6.51	7.90	1.36	1.82
Soy-bean cake	New South Wales Department of Agriculture.	6.77	8.23	1.33	2.00
Soy-bean meal [1]	Elizabeth City Cotton Oil Mills, North Carolina.	7.24	8.79	1.44	1.85
Soy-bean meal [2]	do	7.72	9.37	1.36	1.82
Cottonseed meal	Average of 204 analyses	6.79	8.24	2.88	1.77

[1] From seed grown in 1914. [2] From seed grown in 1915.

While soy-bean meal, as shown in Table IX, has a high value as a fertilizing material, a more economical practice would be to feed the meal to stock and apply the resulting manure to the soil. Feeding experiments indicate that much of the fertilizing value of feeds is recovered in the manure.

USES OF SOY-BEAN OIL.

The oil extracted from the soy bean belongs to the semidrying class of oils; that is, those having properties intermediate between drying oils, such as linseed oil, and nondrying oils, such as olive oil. This oil has a good color, has but a faint odor, and is rather palatable. In many respects it resembles cottonseed oil, but is of a more pronounced drying character. With the rapid growth of the soy-bean

industry many new trade uses for the oil have been found, and on account of its lower cost it has become an important competitor of other vegetable oils.

One of the principal uses of the oil in Asiatic countries, chiefly China, is for food, it being consumed largely in the crude state by the poorer classes, but among the rich it is boiled and allowed to stand until clarified. The oil is also utilized in the Orient in the manufacture of foodstuffs, paints, waterproof goods, soap, varnish, and printing ink, and for lubricating and lighting.

Soy-bean oil was at first used in Europe and America in its crude state principally in the manufacture of soft soaps. It is now claimed that some soap manufacturers have a secret process by which the oil can be utilized in the manufacture of the best grades of hard soap. To some extent it is being refined and placed on the European markets as an edible table oil. The refined oil is also used in the manufacture of butter substitutes, and in the Mediterranean countries to blend for salad oil. In the search by manufacturers for new oils to replace linseed oil for paint purposes partly or wholly, soy-bean oil was found the most suitable. In Europe and the United States, paint grinders are using large quantities of soy-bean oil successfully in the manufacture of certain types of paint. Other trade uses of this oil are the manufacture of linoleum and of a rubber substitute, for which a factory has been established in Germany.

As the process of refining soy-bean oil is improved and perfected there seems to be scarcely any use in which oil has a part in the manufacture of foodstuffs to which it will not be an important adjunct.

Soy-bean oil has been studied with other oils in a series of experiments carried on by the Office of Home Economics and found to compare favorably with the more common culinary table oils with respect to the thoroughness with which it is assimilated.

ANALYSES OF IMPORTANT VARIETIES OF SOY BEANS.

Chemical analyses indicate that considerable variation in composition exists among varieties of soy beans. In determining the range in the oil and protein contents of over 500 varieties grown in the variety tests at Arlington Farm, Va., the percentage of oil was found to range from 11.8 to 22.5 and of protein from 31 to 46.9. The composition of the principal varieties grown in the United States shows a very wide range in the percentage of oil (11.8 to 20.3) and also of protein (34.1 to 46.9) when grown in any one locality. At the present time the Mammoth Yellow variety is most generally grown throughout the South and is the one used in the production of oil. The yellow-seeded varieties, which are most suitable for the production of oil and meal, contain the highest percentage of oil.

Environment has been found to be a potent factor in the percentage of oil in the same variety.[1] Considerable differences occur in oil content when soy beans are grown in different localities. The Haberlandt variety grown in Mississippi, North Carolina, Missouri, Virginia, and Ohio gave the following percentages of oil, respectively: 25.4, 22.8, 19.8, 18.3, and 17.5; while the Mammoth Yellow variety grown in Alabama, South Carolina, Tennessee, North Carolina, and Virginia gave, respectively, 21.2, 19.6, 19.5, 18.4, and 18.8. Variety tests conducted in various parts of the country indicate a higher percentage of oil with the same variety for southern-grown seed. Similar results have been obtained in Manchuria, the North Manchurian beans showing an oil content of 15 to 17 per cent and the South Manchurian beans from 18 to 20 per cent.

The soy bean lends itself readily to improvement by breeding, and experiments indicate the possibility of securing varieties of high oil content by selection. Individual plant selections from a Manchurian variety grown at Arlington Farm, Va., varied from 20.2 to 25.5 per cent in oil content. Analyses of a large number of plant selections from the Mammoth Yellow variety, grown under identical conditions in the same field, showed variations in oil content from 18.1 to 20.4 per cent. It is apparent that there is considerable variation in oil content of the same variety, and an opportunity is offered for developing strains of high oil content. (Table X.)

TABLE X.—*Analyses for protein and oil of important varieties of soy beans grown at Arlington Farm, Va., Newark, Del., and Agricultural College, Miss.*

Variety.	Fat.			Protein.		
	Virginia.[2]	Delaware.[3]	Mississippi.[3]	Virginia.[2]	Delaware.[3]	Mississippi.[4]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Mammoth	18.6	.....	18.6	37.6	.....	41.4
Hollybrook	16.8	16.8	18.5	40.0	40.0	39.0
Manchu	19.2	.....	.....	37.2	.....	.....
Haberlandt	18.3	18.7	.....	38.5	38.2	.....
Medium Yellow	19.3	17.6	.....	34.1	40.0	.....
Ito San	16.6	16.9	17.4	40.3	40.5	39.6
Chiquita	17.6	.....	.....	46.9	.....	.....
Tokyo	18.4	.....	20.7	35.0	.....	38.1
Lexington	19.1	17.3	.....	34.5	39.1	.....
Guelph	19.5	.....	20.2	36.8	.....	40.3
Black Eyebrow	17.8	.....	.....	40.8	.....	.....
Shanghai	18.4	.....	18.5	35.6	.....	41.4
Peking	15.9	17.2	16.4	39.0	36.4	40.1
Wilson	18.4	18.8	17.5	37.8	37.0	39.3
Biloxi	.....	.....	20.3	.....	.....	46.3
Barchet	11.8	.....	15.7	45.9	.....	41.0
Virginia	17.8	.....	17.9	40.2	.....	40.6

[1] Garner, W. W., Allard, H. A., and Foubert, C. L. Oil content of seeds as affected by the nutrition of the plant. *In* Jour. Agr. Research, v. 3, no. 3, p. 227–249. 1914.

[2] Analyses made by Mr. H. A. Piper, Bureau of Chemistry.

[3] Grantham, A. E. Soy beans. Del. Agr. Exp. Sta. Bul. 96. 39 p., illus. 1912.

[4] Robert, J. C. Preliminary report on the economic value of the soy bean, p. 4, tab. 1. Miss. Agr. Coll., 1915.

POSSIBILITY OF DEVELOPING A MANUFACTURING INDUSTRY WITH AMERICAN-GROWN SOY BEANS.

The large annual importations of soy beans, oil, and cake into the United States during the last few years indicate a ready market for products obtained from American-grown beans. The demand for the oil, especially in the manufacture of soap, and its possibilities in the manufacture of paints are very large, and it should be a strong competitor of other vegetable oils, for which the demand is constantly increasing both in this country and in Europe. When the meal becomes properly recognized as a feed material for the production of beef and butter, there will be practically an unlimited market for it as feed. In the dairy countries of Europe, oil meals form a most important part in the stock rations. Denmark feeds more than a tenth of a ton of cottonseed cake (besides other kinds of oil cake) per head of cattle per year. If the cattle in the United States were to be fed at the same rate, the total oil cake or meals of all kinds produced in this country would be insufficient to supply the demand. The numerous experiments being conducted in the preparation of soy-bean products for human food will doubtless result in a much larger use of the meal for this purpose.

It is not expected that the soy-bean industry will develop in the near future to the extent attained in Manchuria. This industry should, however, develop gradually and the soy bean become an important crop in the regions most favorably situated for seed production, especially the cotton belt. Since the boll weevil first entered Texas in 1892, it has been an increasingly important factor in the annual production of cottonseed. At the present time the weevil is found more or less extensively in Texas, Louisiana, Mississippi, Oklahoma, and Alabama and is annually extending its range from 40 to 70 miles. From available statistics it has been estimated that the weevil causes a reduction of at least 50 per cent of the cotton crop in regions invaded by it. As the range of the weevil is gradually extending eastward, where conditions are more favorable for greater damage to the cotton crop, it is readily seen that the quantity of cottonseed available for oil and meal production will be affected to a greater or lesser extent. In Table XI the effect of the boll weevil on the production of cottonseed is plainly shown. The soy bean offers an excellent opportunity to the planter to adjust his plantation management so that he can offset the weevil damage and with profit to himself furnish the cotton-oil mill owners a source of oil and meal.

TABLE XI.—*Acreage, production, and value per ton of cottonseed in the boll-weevil States.*[1]

[The numbers printed in black-faced type indicate the beginning of boll-weevil invasion.]

Year.	United States.			Louisiana.		
	Acres.	Cotton-seed.	Value per ton.	Acres.	Cotton-seed.	Value per ton.
		Tons.			*Tons.*	
1899	24,275,101	4,668,000	$10.28	1,376,254	338,388	$10.29
1902	27,114,103	5,092,000	15.75	1,617,586	422,685	13.50
1903	28,016,893	4,716,000	17.82	1,642,463	395,000	18.74
1904	30,053,739	6,427,000	14.15	**1,745,865**	521,000	13.93
1905	26,117,153	5,060,000	14.89	1,561,774	246,000	15.97
1906	31,374,000	5,913,000	13.76	1,739,000	440,000	12.39
1907	31,311,000	4,952,000	17.64	1,622,000	300,000	16.00
1908	32,444,000	5,904,000	15.65	1,550,000	209,000	16.41
1909	32,044,000	4,462,000	27.96	957,000	112,000	29.28
1910	32,403,000	5,175,000	27.60	975,000	109,000	26.42
1911	36,045,000	6,997,000	18.21	1,075,000	171,000	18.59
1912	34,283,000	6,104,000	21.03	929,000	167,000	22.15
1913	37,089,000	6,305,000	24.84	1,244,000	197,000	20.66
1914	37,406,000	7,186,000	17.93	1,340,000	200,000	18.60

Year.	Mississippi.			Texas.[2]		
	Acres.	Cotton-seed.	Value per ton.	Acres.	Cotton-seed.	Value per ton.
		Tons.			*Tons.*	
1899	2,897,920	634,083	$10.55	6,960,367	1,262,651	$9.82
1902	3,183,989	691,007	14.60	7,640,531	1,198,140	15.00
1903	3,327,960	686,000	18.72	7,801,578	1,185,000	17.95
1904	3,632,458	861,000	15.57	8,355,491	1,507,000	14.32
1905	3,051,265	574,000	15.49	6,945,501	1,219,000	12.75
1906	3,408,000	680,000	12.41	8,894,000	1,858,000	12.50
1907	3,220,000	652,000	15.50	9,156,000	1,024,000	17.35
1908	**3,395,000**	736,000	15.64	9,316,000	1,698,000	13.91
1909	3,400,000	481,000	29.50	9,930,000	1,122,000	26.16
1910	3,317,000	561,000	28.69	10,060,000	1,356,000	24.60
1911	3,340,000	535,000	20.01	10,943,000	1,893,000	17.70
1912	2,889,000	465,000	24.39	11,338,000	2,171,000	18.28
1913	3,067,000	583,000	24.77	12,597,000	1,755,000	23.02
1914	3,100,000	553,000	18.69	12,052,000	2,043,000	15.30

[1] Compiled from U. S. Dept. Com., Bur. Census Bul. 10 (Quantity of cotton ginned in the United States, 1899–1903), 1904; Bul. 111 (Cotton production and statistics of cottonseed products: 1910), 1911; Bul. 131 (Cotton production and distribution, 1914–15), 1915.

[2] The boll weevil entered Texas in 1892.

Although the seed is the factor of prime importance, the improvement to the soil from growing a legume and using the straw as feed should be considered in estimating the value of the crop. In view of the short working season and the fact that no additional equipment is essential in using the soy bean, it seems that the soy-bean oil and meal industry should become an important adjunct of the cotton-oil mills.

The soy-bean industry has gained such importance in Europe that the various countries have been conducting extensive investigations in their African colonies for the production of seed in competition with the Manchurian beans. When soy beans were first imported from Manchuria, the price was about $24 per ton on the European market, but the competition of the European countries for the raw product brought the price quickly to $45 per ton, and during the last three years quotations on the different markets average about $40 per ton.

At these prices it was found that the African colonies were in a favorable position to compete with the bean growers in Manchuria.

Moreover, it is evident that the farmer in America is able to compete on the European and home markets both with the Manchurian and the African bean at the prices prevailing during the last three or four years. Although the cotton-oil mills in the United States estimate that the soy bean can not be worked profitably at a much higher price than $1 per bushel, and then only when the price of cottonseed is higher, available statistics (Table XII) show that the oil mills in Europe have been paying in many instances higher prices for soy beans than for cottonseed.

Although the selling price f. o. b. Manchurian ports ranges from $30 to $35 per ton, the transportation makes the price approximately $40 at American and European ports. If the American grower can raise the beans profitably at $1 per bushel of 60 pounds, the higher yields of seed obtained in this country and planting and harvesting by machinery should enable him to compete on the European market.

TABLE XII.—*Comparative prices per ton of cottonseed and soy beans on the European market, 1911 to 1914, inclusive.*

Country.	1911		1912		1913		1914	
	Soy beans.	Cotton-seed.	Soy beans.	Cotton-seed.	Soy beans.	Cotton-seed.	Soy beans.	Cotton-seed.
United Kingdom	$35.18	$35.86	$40.42	$37.07	$40.47	$36.76	$40.57	$33.63
Germany	37.48	38.78	41.37	39.77	36.97	40.37	37.40	.....
Average	36.33	37.32	40.89	38.42	38.72	38.56	.....	.....

NOTE.—These figures represent the average price per ton as shown by the importations and valuations of these crops in the Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions and in the Statistik des Deutschen Reichs.

The soy bean is already a crop of high value in American agriculture and seems destined to be of far greater importance, especially in the cotton belt, not only as a cash crop but as an aid in maintaining the fertility of the soil. With a mutual understanding of the possibilities of the soy bean and its products, the industry should become a most important one in conjunction with the cottonseed-oil industry.

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